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COLLES'S FRACTURE.

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COLLES'S FRACTURE.

A SHORT time since the body of a female subject was brought into the dissecting room of the College of Surgeons' School, in which the radius of each side was found to present the evidence of former fracture of the lower extremity, united with unreduced deformity, and I thought that a description of the specimens might be worth bringing under the notice of the Surgical Society, as both presented peculiarities which contrasted with the usual and typical form of fracture occurring in this situation, and with which the name of one of the greatest of Irish surgeons is so deservedly connected. I also thought the occasion a favourable one for giving a short *résumé* of the literature of the subject, on which it is said that more has been written than on any other similar lesion occurring in the human body.

Of the pair of specimens in question, the radius of the right side had been the seat of an oblique fracture, the obliquity, as is usually the case, running from above and behind downwards and forwards, but at a much higher level than is generally seen, the line of fracture being in front, an inch and three-quarters above the carpal extremity of the bone, whilst on the posterior aspect, it reached to a little more than two inches from the articular margin. The lower fragment had been, so far as I could make out, simply hinged backwards with the slightest possible amount of separation of the broken surfaces, and a vertical antero-posterior section showed no trace of the line of compact tissue imbedded in the spongy structure of the

lower fragment, which was believed by Voillemier to be conclusive evidence of impaction. The carpal fragment had also undergone the peculiar form of rotation described by Goyrand, in which the triangular fibro-cartilage forms the radius of a circle, of which the lower piece of the broken bone describes an arc during the progress of displacement, so that the outer side of the lower fragment is carried further backwards than the inner. A remarkable complication existed in the form of a dislocation of the scaphoid bone, which had been rotated on its vertical axis, so that the tuberosity looked backwards and outwards, forming a prominence below and a little *behind* the styloid process of the radius.

The fracture on the left side had been at a lower level, the solution of continuity being placed in front about an inch above the lower end, while it reached about one-third higher posteriorly. On neither side did any evidence of impaction exist, but this is not to be wondered at, as even Voillemier himself, the great apostle of the impaction theory, says that it is not to be expected in fractures more than an inch or so above the articular extremity.

Although the name of Colles is in this country invariably associated with the usual form of solution of continuity of the lower end of the radius, the frequency of the occurrence of fracture in this locality was pointed out long before by Pouteau, whose description of the signs of this lesion in the second volume of his "*Œuvres Posthumes*," will be found to contain a very excellent description of the most prominent local signs of the lesion. His pithy remark that this is of all fractures the one in which a diagnosis can be most certainly made by a single *coup d'œil*, has become a household word in surgery; but his theory of the mechanism of the fracture, that it was due to a spasmodic contraction of the pronator and supinator muscles of the forearm, will not find many supporters at the present day. He ingeniously compares the articulated bones of the forearm to a segment of a circle, of which the arch

is represented by the radius, whilst the cord is formed by the ulna, and so demonstrates—to his own satisfaction at least—that the action of the pronator muscles on the curved bone in approximating the fragments to the ulna, must be to produce lengthening of the broken radius. To this imaginary lengthening it is that he attributed the peculiar displacement of the carpus which he mentions as the first of the characteristic signs of the lesion. The other typical changes which he enumerates are: the tumour on the palmar aspect of the forearm, caused, as he thought, by contraction of the pronator quadratus, throwing forwards the flexor tendons; thirdly, diminished breadth of the forearm at the seat of fracture from the action of the same muscle causing approximation of the fragments, and consequent obliteration of the interosseous space; and fourthly, increased size of the wrist, produced by the *mouvement de la bascule*, communicated to the styloid process of the broken bone.

He also remarks that it is not necessary to expect much displacement, but a depression of the arch at the seat of fracture, which is aptly compared to the *lezarde* or *baillement* of architectural ornamentation.

Yet, strange to say, notwithstanding Pouteau's recognition of the importance and frequency of fractures of the lower end of the radius, we find his teaching on the subject absolutely ignored by subsequent authorities in French surgery for a very considerable period. Boyer writing in 1803^a and subsequently in 1820^b does not seem to be aware of the existence of such a lesion, and although he speaks of fractures of the radius produced by a fall on the hand, he places the seat at the centre of the shaft of the bone.

In Desault's *Journal de Chirurgie* in 1790, there had appeared, indeed, a record of a single case of fracture of the lower end of the radius, observed by Herne, but the case is merely noted, without further comment, and the writer docs

^a Mal. des os.

^b Dict. de Med.

not make the smallest allusion to Pouteau's description. Most of the leading surgical authorities of the time followed the old errors; the four luxations of the wrist were unanimously recognised, their characteristic signs pointed out, and appropriate treatment recommended.

It was in 1820 that Dupuytren, by the immense influence of his writings and lectures, succeeded in establishing—for French surgeons at least—the non-existence of luxation of the wrist, of which he had never seen an example throughout the whole of his enormous experience; and the frequency of fractures of the carpal extremity of the radius, which formed a fifth of the cases occurring in his practice. So completely was the work of foreigners in this direction ignored by French writers, that we find Voillemier, in 1842, giving Dupuytren the credit of having *created*, so to speak, fracture of the lower end of the radius.

It was in 1814 that the short but valuable description of Professor Colles appeared in the pages of the *Edinburgh Medical and Surgical Journal*, and with the exception of the single point of his localisation of the level of the seat of fracture, which he placed an inch and a half above the carpal extremity of the bone, his account of the lesion has suffered but little at the hands of subsequent critics. Colles was not then aware that any previous account had been published, and wished to call the attention of surgeons to the frequency of the occurrence of a solution of continuity of the lower end of the radius, and the extreme infrequency of the forward (or so-called Desault's) dislocation of the carpal extremity of this bone, for which this injury had been mistaken, because the "absence of crepitus" and other signs of fracture, together with the swelling which instantly arises in this as in other injuries of the wrist, render the difficulty of ascertaining the real nature of the case very considerable. He points out the depression which is seen about an inch and a half above the end of the radius, the swelling and backward displacement

of the wrist and metacarpus, the fulness of the anterior surface of the forearm limited below by the anterior annular ligament of the wrist, and apparently caused by the flexor tendons being thrown forwards, and the projection of the lower end of the ulna towards the palm and inner side, to a degree varying in different instances. The lower end of this bone can also be moved backwards with abnormal facility; but an examination of the radius at the seat of fracture fails to detect either crepitus or yielding of the fragments till extension is made, so as to restore the limb to its natural form, when a backward and forward movement will be found to cause a sensible yielding of the broken surfaces. The inward projection of the lower end of the ulna he attributed to the pressure of the upper end of the carpal fragment of the radius, the yielding of the other bone being facilitated by laceration of the ligaments of the inferior radio-ulnar articulation. Such is Colles's account of his own fracture. Imperfect it of course is, but for an original description we cannot but admire the sagacity with which he appreciated, and the happy simplicity and clearness of language with which he detailed, the diagnostic value of the local signs of this lesion.

The teaching of Pouteau in France, and of Colles in this country, was comparatively neglected till the subject was revived by Dupuytren, and by R. W. Smith, and it is indeed to the widespread influence of the opinions and writings of these eminent surgeons that may chiefly be attributed the prominence which has been accorded in the literature of the profession since their time to the consideration of this, the most frequent—at least, according to some authorities—of the fractures that have been met with in the human skeleton.

While Colles had contented himself with pointing out the comparative frequency of fracture, and the rare occurrence of dislocation, Dupuytren went so far as to doubt—although not of course absolutely deny—the possibility of the occurrence of a luxation occurring at the radio-carpal articulation; and

amusing stories are still recorded of the fierce clinical disputes which sometimes took place on the subject, even in presence of the patients, between the hot-tempered surgeon of the Hotel Dieu and his colleagues, Pelletan and Marjolin, both of whom remained for a long time orthodox believers in the errors which had been impressed on them by their earliest surgical teachers. In one case a man who had fallen on the extended hand was brought into the hospital presenting the characteristic deformity of the lower end of the forearm, and the case was examined by both Marjolin and Dupuytren. The former diagnosed a luxation of the carpal bones; the latter a fracture of the radius. Neither was disposed to yield in the least to the opinion of the other, when an opportunity was afforded of settling the point by the death of the patient from some intercurrent disease. The autopsy was made in the presence of the two champions. The victory remained with Dupuytren.

In the description which is published in the *Lancette Française* in the year 1820, he notices the change in the axis of the forearm, and also in that of the hand, which is carried to the radial side by a movement of *abduction de totalité*. The projection of the lower end of the ulna he refers to the displacement of the hand. He points out the anterior and posterior tumours, the former of which he refers to the angular projection of the fragments in front, and the latter to the prominence of the carpus behind. He also adds that in those cases where an opportunity had been afforded of examining the recent specimen, he always found the inferior fragment divided by radiating lines into several pieces, as if it had been violently struck with a hammer, a condition to which he applied the term, *fracture par écrasement*. He places the seat of fracture at two or three lines, up to half an inch, rarely so high as an inch or more, above the lower end of the bone, but makes no reference to the obliquity of the line of fracture. In the *Leçon's Orales* he points out the remarkable analogy which exists between this fracture and that of the lower end of

the fibula, with which the name of Pott is now so generally associated, and traces the prominent points of resemblance of the two lesions. The abduction of the hand in one case is compared to the eversion of the foot in the other. The projection of the lower end of the ulna has its counterpart in the prominence of the inferior extremity of the tibia; the depression at the seat of the radial fracture resembles the *coup de hache* which is found above the external malleolus; while the action of the long abductor muscle of the thumb (extensor ossis metacarpi pollicis) is supposed to have an influence on the carpal deformity in the case of the lesion of the upper extremity similar to that which is exercised on the distortion of the foot by the peronei muscles in case of a solution of continuity of the lower end of the fibula.

The fact that the radius alone gives way, Dupuytren accounts for by observing that it is the bone which offers the greater resistance, as it only articulates with the wrist, and accordingly deserves the name, which was given to it by the old anatomists, *manubrium manus*. By this anatomical arrangement the radius is made to receive all the force which is communicated to the upper extremity by a fall on the hand. The situation of the fracture at the lower end, in spite of the greater thickness and apparent strength, will be understood when it is remembered that the whole violence of the shock is concentrated on that part of the bone, and that the increased thickness does not by any means denote greater solidity, as the osseous tissue at the favourite seat of the lesion is almost purely cancellous. The liability to fracture is also vastly increased by the almost complete impossibility of dislocation, which is explained by the immense resisting power offered by the tendons, both flexors and extensors, which are closely applied to the surfaces of the radio-carpal articulation. If, as the writer believes, a force of 2,000 lbs. would be insufficient to overcome the resistance, a fall under ordinary circumstances will fail to do so, for the momentum or moving force, calculated

by multiplying the weight of the body by the velocity of the fall, will not, except in cases where it has been from a great height, give so large a figure as the one mentioned. A violent fall on the hand, then, if not followed by a dislocation of both bones backwards at the elbow-joint, nearly always produces a fracture of the lower end of the radius. Sometimes the result may be found to be a severe sprain of the wrist-joint, or fracture of some of the phalanges or metacarpal bones, but these are not often seen.

The example of M. Bouchut, who, in his thesis, published in 1834, gave the results of a series of experiments on the cadaver, was followed by a host of other inquirers, who endeavoured, by such method, to throw some new light on the mechanism of this still obscure lesion. Goyrand (d'Aix) had, indeed, been in the field before him, but had not done so much. He, however, made his views and experiments the subject of a very valuable communication to the *Gazette Médicale* in the year 1832. He lays great stress on a point which had been neglected by Dupuytren—that is, the obliquity of the line of fracture, which, according to him, takes, in nineteen cases out of twenty, a direction from above and behind, downwards and forwards. He also makes three varieties of this fracture (1) by far the most frequent in which the line of fracture runs obliquely from behind downwards and forwards; (2) comparatively rare, in which the line of obliquity runs from the anterior aspect of the bone downwards and backwards; and (3) the *en étoile* of Dupuytren. In the first of these forms the lower fragment glides on the inclined plane formed by the oblique surface of the other, and so becomes displaced upwards as well as backwards, either by muscular action alone, or by the violence which had produced the fracture persisting after the solution of continuity had been established. In the latter case the displacement, of course, would be much more considerable. At the same time, as the lower fragment is still tied to the ulna by the triangular fibro-cartilage, it is obliged

to undergo a rotatory movement, in which it describes an arch of a circle, of which the radius is formed by the fibro-cartilage, the centre being at the ulnar extremity of the same. By this double movement, the articular surface undergoes a change of direction, so that instead of looking forwards and inwards, it becomes inclined backwards and outwards. In the second form of fracture, analogous phenomena are met with, excepting that the forward deviation of the lower fragment is less pronounced than the backward in the other case, and that the direction of the articular surface is turned still more forwards than in the normal condition. With regard to the abduction of the hand, he expresses very strongly an opinion directly opposed to that of Dupuytren, who looked upon this deformity as one of the most characteristic signs of fracture of the lower end of the radius. Goyrand, on the other hand, considers its occurrence to be quite exceptional, and insists that so long as the internal lateral ligament of the wrist and styloid process of ulna remain whole, the hand will be found to be inclined not outwards but inwards; whilst he admits that in the rarer cases in which the ligament has been torn by an extreme amount of violence, or the styloid process wrenched from the head of the ulna, the axis of the displaced hand will be found to have undergone some deviation to the radial side of the forearm. The mechanism of the fracture is referred by this writer to *contre-coup*. In a fall on the palm of the hand the whole weight of the body is thrown on the upper extremity. The carpus, broken up into a great number of pieces by movable articulations, decomposes the shock, and resists it; but the radius, pressed between the weight of the body, and the carpus, supported by the ground, receives the transmitted force at its inferior extremity, where from the sponginess of its structure, it is least able to resist. The opinion of Goyrand on the relative frequency of this fracture is somewhat remarkable, for he roundly asserts that the number of specimens admitted to the Hôpital d'Aix, bore to the number of all other fractures

taken together, the proportion of one to two, at the same time observing that many genuine cases escaped observation, because the patients, looking upon the injury as a sprain, did not apply at the hospital for surgical assistance.

In a communication made a few years later to the *Archives Gènèrales de Médecine*, Diday discusses at greater length the mechanism of this fracture. This he tried to define with mathematical precision, and explains the obliquity of the line of fracture by the decomposition into two forces of the action of the weight of the body in falling, on the radius inclined to the ground at an acute angle. According to the law of parallel forces, one of these is parallel to the ground, and is necessarily and completely neutralised; the other is perpendicular to the same plane, and is consequently the only one which is able to act. But this vertical force intersecting the shaft of the radius in the oblique position into which it is naturally thrown at the moment of falling, "it is clear that the solution of continuity ought, as in all fractures by *contre-coup*, to follow the same direction as that of the force which produces it, and in this case will follow an oblique line running downwards and forwards in relation to the radius, considered in the position which it occupies in the subject in the vertical posture." The same explanation applies to the reverse obliquity of the line of fracture in the rarer cases where it is produced by a fall on the back of the hand. He also lays much stress on the shortening of the broken radius, which is produced by the over-riding of the fragments, and, in his experience, was invariably present, amounting in some cases to five or six lines. The backward displacement of the carpus, and the projection of the inferior extremity of the ulna in front are also pointed out. The shortening of the radius has the effect of throwing the surfaces of the inferior radio-ulnar articulation out of their mutual contact, and hence the difficulty of the movements of pronation and supination, which so often remains for a considerable period after the union of the fracture.

In 1842, Velpeau, in his article on the subject in the *Dictionnaire de Médecine*, occupied himself chiefly with the consideration of the diagnosis, and pointed out two new signs which, he believed, would secure the practitioner from every possible error. The first of these is the constant deformity “*en Z*,” which, he believed, to be pathognomonic of fracture of the lower end of the radius ; the second is the elevation of the external radial tendons, which, instead of lying, as in the normal state of the parts, close to the surface of the bone, come to stand out prominently beneath the skin, separated from the back of the lower part of the radius by an interval of six or eight millimetres. The **Z**-shaped distortion is manifest, whether the affected limb be viewed in profile, or antero-posteriorly. In the former aspect, one branch of the **Z** is formed by the axis of the radius, the other extreme, by the vertical axis of the carpus, while the intermediate link is represented by a line from the inferior extremity of the prominence formed at the seat of fracture in front, to the superior extremity of the carpal prominence behind. The general outline of the back of limb in the vicinity of the seat of fracture he likens to that of a dinner-fork.

This same year of 1842, marks an epoch in the literature of fractures of the lower end of the radius, for it saw the publication of the important *memoire* of Voillemier, the most elaborate and exhaustive which has yet appeared on the subject. According to this ingenious writer, the most frequent form of fracture met with in this situation is what he has described under the name of *fracture par penetration*. For the correct understanding of his hypothesis, we must make ourselves acquainted with the exact structure of the lower end of the radius. The layer of compact tissue, which forms nearly the whole thickness of the shaft of the bone at its middle, rapidly diminishes in thickness as it approaches the carpal extremity, and, for the last centimetre, is nearly as thin as ordinary parchment. In front a layer of tolerable thickness is prolonged a little farther

down than on the posterior surface. Accordingly, in a fall on the hand, when the force is transmitted directly from the carpal bones to the lower end of the radius, a solution of continuity is immediately established at the place where the investing wall of compact tissue has nearly ceased to exist, and the continuation of the force causes the solid tube of compact tissue to penetrate the substance of the spongy mass beneath. If the force has been moderate, the degree of impaction is slight, merely causing a firm interlocking of the fragments; whereas, if the violence happens to be extreme, the superior fragment continuing to descend, crushes the carpal portion between it and the bones of the wrist, and dividing it into a number of pieces, establishes the condition described by Dupuytren under the name of *fracture par écrasement*. In the great majority of cases, however, according to this writer, the oblique position of the limb causes the force to tell more effectually on the posterior part of the articular end of the bone, and, especially, because this part rests more directly on the carpal bones, and is placed more in a line with the axis of the shaft of the radius. Accordingly, the impaction of the upper into the lower fragment commences posteriorly, while the latter is, at the same time, carried somewhat backwards; while the posterior wall of the upper fragment penetrates the spongy tissue of the lower, the anterior, on the contrary, overlaps the latter in front, so that the impaction is reciprocal. When examined from within outwards, a similar disposition is found. The outer border of the brachial fragment will be found penetrating the carpal piece in the direction of a vertical plane, which, if prolonged, would separate the styloid process from the shaft of the bone, while the inner margin, on the contrary, is seen to override that of the lower fragment. The obliquity of the plane of fracture, then, according to Voillemier, is really apparent, and the delusion is due to the backward deviation of the lower fragment, and the greater depth of the posterior penetration. The evidence on which he relies as

being absolutely conclusive of the truth of his theory, and which he never failed to find when looked for, is a vertical line of compact tissue, imbedded in the cancellous structure of the lower fragment, and which, when traced upwards, is found to be directly continuous with the investing layer of the shaft of the bone. In the rarer cases in which the lower fragment is displaced forwards, the line of compact tissue is found to be continuous with the anterior wall of the shaft, but in no case is a second line present even when the carpal fragment has undergone the smallest possible amount of deviation from its normal axis. From the apparent dilemma offered by the latter case, Voillemier extricates himself by pointing out that although reciprocal penetration always takes place, the compact covering of the lower fragment is so extremely fragile that it offers no resistance, and is, in a great measure, broken up at the time of the injury. Another mechanism is recognised by this writer in explanation of the occurrence of a much less frequent form of fracture which is met with in the same vicinity. Experiments on the cadaver had proved to him that extreme flexion or extension of the hand nearly always had the effect of wrenching off a piece of the lower end of the radius, and, in this way, he believed, should be explained the epiphysary disjunction so often seen in young subjects. In more advanced life, a fracture occurring in this way, sometimes engaged the articular surface, and removed an oblique slice, either anteriorly or posteriorly, and, in other cases, detached a fragment of the usual length from the whole thickness of the bone. In none of these cases, according to Voillemier, is there any considerable deformity, and, accordingly, to the class of *fractures par arrachement*, he would relegate all those cases in which, after a history which would lead to a suspicion of fracture, the predominant symptoms indicate merely the existence of a sprain, where deformity and crepitus are absent, and an obscure mobility is the only local sign justifying the opinion that a solution of continuity of the bone has taken place. He narrates two very

remarkable cases in point : one in which a fall on the anterior surface of the lower half of the hand was the cause of the fracture, and a second, where a very powerful young man had had his wrist violently flexed by one of his comrades in playing. In both the signs were of the obscure kind above described.

With regard to the local signs of the typical form of fracture, Voillemier insists that the abduction of the hand on which Dupuytren laid so much stress, is more apparent than real. In those cases in which it is most pronounced, the axis of the hand is merely brought to approach that of the forearm, but in the great majority of the cases, the hand completely preserves its normal position of adduction. He dwells at some length on the antero-posterior distortion of the limb, in which the long axis is broken up into three parts, forming so many inclined planes meeting at obtuse angles ; one formed by the upper fragment, a second, by the lower, and a third, by the carpus and metacarpus. The radial border of the limb will be found, on examination, to present a similar deformity, so that laterally, as well as antero-posteriorly, a single *coup d'œil* will suffice to recognise the characteristic Z-shaped deformity, as it was happily described about this date by Velpeau. Voillemier entirely rejects the rotatory movement of the lower fragment around the triangular fibro-cartilage so carefully described by Goyrand, as well as the *mouvement en bascule*, of Pouteau ; while the absence of mobility and crepitus, as well as the unmistakable distortion, are accounted for by the mutual impaction of the fragments of the broken bone.

Nélaton, in his "Pathologie Chirurgicale," published in 1844, adopts the impaction theory of Voillemier, with the slight modification that reciprocal impaction is very rare, the brachial fragment alone penetrating the other, and only at the posterior part. He also makes the plane of fracture transverse ; but, contrary to Voillemier, considers abduction of the hand to be frequently present. The triangular fibro-cartilage generally loses its attachment, either from laceration of its fibres, or

fracture of the styloid process of the ulna, and so shortening of the radius is allowed to take place, with a semi-luxation of the inferior radio-ulnar articulation. He describes in terms more clear, perhaps, than those of any preceding writer on the subject his ideas of the mechanism of the fracture. The forearm, in a fall on the hand, forming a right angle with the latter, comes to press directly on a kind of arch formed by the first row of carpal bones, and the latter resists in supporting itself (1) on the ground by its internal extremity formed by the pisiform; (2) on the trapezium by its external pillar which is formed by the scaphoid; (3) on the centre formed by the os magnum and unciform. The radius being pressed between the weight of the falling body on one side, and the resistance of the ground transmitted through the carpal bones on the other, yields at a short distance from the articulation.

We have already referred to Bouchut's account of his experiments on the dead body with the view of deciding the question of the possibility of producing a dislocation of the wrist-joint. He sacrificed to his zeal for truth, both forearms of twenty bodies, but all his efforts to obtain a carpal luxation were useless, the radius, in every case, gave way either to extreme flexion or extreme extension, more easily to the latter. Malgaigne had previously (in the year 1832), firmly denied that there was any such thing on record as a *bona fide* example of dislocation of the wrist, and after examination, rejects summarily the only three cases which the literature of surgery then afforded, and which had been reported on the authorities of Ravaton, Thomassin, and Cruvelhier respectively. Roquetta two years later, in a valuable essay on the subject, arrives at the same conclusion, and adds some judicious remarks on the epiphysary separation which occurs in children.

Bonnet (de Lyon), writing in 1845, gives the results of his experiments on the cadaver, with the object of producing fracture of the radius by forcible extension of the hand. He was nearly always successful in establishing a solution of

continuity; but in only one of eight cases did deformity co-exist with the other signs of fracture. He never succeeded in procuring fracture of the end of the radius by flexion of the hand. He ruptured tendons and ligaments, and sometimes even fractured some of the carpal bones, but made no impression on the bones of the forearm.

In 1846, the views of Voillemier, which now held almost supreme sway, were ingeniously contested by Jarjavay. He asserted that Voillemier had been deceived by the appearances presented by united fractures, from the fact that the periosteum, which is very strong on the posterior surface of the carpal end of the radius, is seldom torn, but being detached for a short distance from the seat of fracture, leaves an interspace, which becomes filled up by spongy osseous tissue.

Malgaigne, in his splendid work on "Fractures and Dislocations," examines the different theories which have been propounded, and gives special attention to three of them:—(1) the inflexion hypothesis of Nélaton; (2) the penetration theory of Voillemier; and (3) that of *arrachement*, to which attention had been already directed by Voillemier and others, but to which Malgaigne accords an importance which it had not hitherto enjoyed.

Verneuil, in 1851, published the result of a series of experiments on the dead body, with the view of determining the conditions which lead to deviation of the hand, and especially abduction. He had been led to believe that the latter deformity could not exist without previous laceration of the triangular fibro-cartilage, or wrenching off of the styloid process of the ulna.

Foucher, in 1852, presented a number of specimens of this lesion to the Société Anatomique, and believes the mechanism of the fracture to be usually that of *arrachement*. Impaction may take place; but he does not look upon it as an essential feature, and the backward displacement of the carpal fragment is explained by the *mouvement de bascule* of Pouteau.

A new and rather paradoxical theory was propounded by M. Lopez in his inaugural thesis of 1860. According to this writer, the interosseous ligament plays the principal rôle in the mechanism of fracture of the lower end of the radius, the position of the solution of continuity being determined by the absence of that supporting membrane near the carpal end of the bone.

M. Lecomte, who undertook the refutation of the thesis of M. Lopez, adopted definitely the theory of *fracture par arrachement*. He combats the idea of Nélaton that the radius gives way because it is caught between two opposing forces, and believes that the columns of support which Nélaton described, do not come to bear upon the surface of the ground at all. This he attempts to prove by the simple experiment of marking with ink on the surface the prominences formed by the pisiform bone and trapezium, and then placing the extended hand on a sheet of white paper; the mark of the pisiform is never reproduced on the paper. The agent in the *arrachement* of the lower end of the radius is the anterior radio-carpal ligament; divide this ligament previously, and no degree of subsequent extension of the hand will affect the radius, nor is the fracture produced by forcible flexion, even when this ligament remains intact. Impaction may or may not exist; it is not by any means an essential feature, and he agrees with Jarjavay, that the preservation of the periosteum posteriorly is a source of subsequent deception, as it leaves a space for the formation of a new layer of osseous tissue between it and the surface of bone beneath, so as to give rise to the idea that penetration had taken place, where it had really never existed.

The testimony of all unprejudiced observers since this date leaves hardly any room for doubt that this fracture may exist either with or without impaction, and also that the differential diagnosis of the two conditions cannot always be made with certainty except in the rare cases where an

opportunity is afforded of examining the specimen. The ablest, as well as the most uncompromising of all the opponents of the Voillemier's theory, was our distinguished fellow-countryman, Robert William Smith. In his valuable work on "Fractures and Dislocations," he upholds with the greatest firmness his belief that the doctrine of fracture with penetration is untenable, and that the distinguished French surgeon has allowed himself to be too easily imposed upon by the fallacious phenomena sometimes presented by consolidated fractures of the lower end of the radius. He believes the occurrence of any appreciable impaction while the ulna remains unbroken, and the ligaments connecting the extremities of the bones are intact, to be a physical impossibility. The position of Voillemier's diagnostic line of compact tissue he explains by sub-periosteal osseous deposition, while he points out another fact of great significance, which seems to have escaped the notice of all previous observers, that the distance between the lamina of compact bone, and the posterior surface of the lower fragment, does *not* correspond to the extent of the backward displacement of that fragment, as it should if the views of the French surgeon were correct. He bases his views on the evidence afforded by examination of more than twenty specimens of "Colles"—one of which was recent—and also points out that the length of the supposed penetrating line of compact tissue does not correspond to the amount of posterior shortening of the radius. The thickening of this layer, which had been observed by Voillemier himself to exist in old fractures, and which he confessed his inability to explain, Smith readily accounts for by the deposition of new osseous matter. The deformity so characteristic of the fracture is referred by the Dublin surgeon to muscular action, while crepitus and mobility, usually so obscure, can, he believes, always be obtained if rotation be judiciously employed, after having previously used an amount of extending force sufficient to remove the deformity. The line of fracture, he believes to be,

in the vast majority of cases, transverse, and even when oblique, he does not admit the possibility of over-riding of the fragments.

Of the most recent contributions to the literature of Colles's fracture, one of the most interesting is that of Chiene, of Edinburgh. To a description of the dissection of a recent specimen, he adds some ingenious remarks on the nature of the mechanism by which the lesion is produced. In falling on the hand, the force which is received chiefly by the ball of the thumb, is transmitted through the carpus to the lower end of the radius. The nature of the lesion then produced will vary with the angle of inclination which the forearm makes with the ground. If this be less than 60° , the line of force travels upwards *anterior* to the axis of the fore-arm, and the whole shock is borne by the lower end of the radius, which gives way near its carpal end. But if at the moment of impact the angle of incidence be greater than 60° , then the line of force, instead of passing in front of, passes directly up the arm, and "the usual result is either a severe sprain of the wrist, or dislocation of both bones of the forearm backwards at the elbow-joint."

This writer admits the existence of a slight degree of penetration in many cases, but not sufficient to justify the application of the term *impaction*, by which he would understand the condition in which the distortion cannot be removed by justifiable force. Such slight penetration did exist in the specimen which formed the subject of the communication, and the thin plate of bone much deeper behind than in front, which had been separated from the end of the radius, was found to be divided by two vertical cracks into three fragments. The tip of the ulnar styloid process was also broken off, but the triangular fibro-cartilage preserved its attachments, and the inferior fragment was found, in addition to the backward displacement, and partial revolution on its transverse axis, to have undergone the rotatory movement, described by Goyrand,

in the arc of a circle, whose centre is placed at the ulnar attachment of the triangular fibro-cartilage.

Dr. Gordon, of Belfast, found as the result of a careful examination of twenty-seven old specimens of Colles's fracture, that the distance of the break varied, posteriorly, from three-eighths of an inch to an inch and three-quarters from the carpal margin, and from two-eighths of an inch to two inches in front. In nineteen cases the fracture was oblique from before backwards, in eight directly transverse. To the question of the existence of impaction he gives no attention, but he argues very strongly in favour of the cross-breaking mechanism of the fracture, produced by the strain of hyper-extension. The idea that the solution of continuity is produced by violence transmitted through the carpus, directly to the end of the radius, he summarily rejects, as he believes that if this were the true explanation the fracture would be found to radiate from the point struck.

The only indisputable evidence which can be collected on the subject of the much-vexed question of impaction, is that derived from the examination of recent specimens. Of the records of such, Dr. Wight, of New York, collected some examples. One is by Professor Hamilton, of New York, in which the autopsy showed the detachment of a considerable fragment from the posterior lip of the articular surface; the direction being upwards and backwards. Two have been reported by Mr. Erichsen; in the first the lower fragment was split into three portions, between which the upper fragment was firmly impacted to the depth of half an inch. The largest fragment of the three comprised the whole of the articular surface, which was uninjured. In the other case the injury had been caused by a fall from a height of twenty-five feet, and the lower fragment, which had been separated by a transverse line about half an inch above the articular end of the bone, was found to be completely comminuted. Two other cases were examined by Professor Gross: in one the

carpal fragment was found to be separated into two pieces by a fissure leading into the joint; in the other, a much more extensive comminution had taken place. In an example recorded by Professor E. M. Moore the fracture was found to be transverse, and although crepitus could not be detected during life there was not the slightest trace of impaction. The tip of the ulnar styloid process had been wrenched off with the internal lateral ligament. In the second forearm of the same body a fracture of the carpal end of the radius was found to exist, which ran in an oblique direction from above and behind downwards and forwards, and the apex of the styloid process of the ulna was torn off.

Dr. Hector Cameron, of Glasgow, has reported the examination of two recent specimens. In the first the line of fracture was transverse from side to side, and oblique from before backwards, the lower fragment being one inch in length behind, and a quarter of an inch in front. The carpal fragment was slightly comminuted, and the lower surface of the upper fragment, which was extremely rough and denticulated, sent a toothed process in the spongy tissue of the lower piece, and so firmly nailed it in its new position, that it required great force to separate them. In Dr. Cameron's second case the fracture was transverse in both directions, and situated about an inch above the carpal extremity. In front the fracture was hardly complete, the periosteum remained untorn; but there was a well-marked backward hinging of the carpal fragment, and an examination of the posterior aspect showed a complete solution of continuity, whilst the compact outer layer of the upper fragment was driven firmly into the spongy tissue of the lower, splitting the latter into three pieces, which it, at the same time, held securely together, the impaction being complete and irreducible.

Dr. Pitcher, of New York, has lately advanced an entirely new theory of the nature and mechanism of fractures of the inferior extremity of the radius. This part of the bone is

formed of "a cone of cancellous tissue, which is grasped above by a cylinder of strong, thick, compact walls. All force transmitted to the lower extremity, other than that of very great intensity, is here finally decomposed and repelled." If, on the other hand, the violence be very great, the carpus acts as "a blunt wedge; driven against the concave articular surface of the radius with sufficient violence, it will split it longitudinally. There is no possibility of a cross-breaking strain being exerted, and if, in any case, transverse lines of fracture are found, they must have been occasioned by some other mechanism." This theory is borne out by the evidence gathered from the examination of eleven specimens of recent fracture, collected in the museum of the New York Hospital, and one in the possession of Professor Hamilton. Ten of the twelve present both vertical and transverse lines of fracture; in some the vertical fissures extend into the shaft above the line of transverse separation. But the most remarkable corroboration of this writer's view was afforded by a specimen presented in 1858 by Professor Bigelow, to the Boston Society for Medical Improvement, in which the carpal articular surface presented a star-shaped crack, from which corresponding fissures passed up into the shaft for more than an inch, but without transverse fracture. This was the second example of the kind that had been met with by Dr. Bigelow.

Among English surgeons of late years, who have taken up the much-vexed question of the mechanism of Colles's fracture, the most decided opinion has been expressed by the late Mr. Callender, who surpasses even Voillemier himself in the vehemence with which he advocates the theory of impaction. Basing his belief on the evidence afforded by the dissection of three cases, in each of which the fracture had been caused by very extreme violence, he considers that "there can be no question but that impaction is the cause of the displacement."

An examination of all the facts and theories which we have collected on the subject will, we think, leave no doubt on

the mind of any unprejudiced inquirer that a great variety exists in the forms, and probably, also, in the mechanism of production, of the fractures of the lower end of the radius. As Professor Bennett has well observed, "we have ample proof that the simple transverse fracture, without impaction, the impacted, and the fracture *par écrasement*, with a shattered lower fragment, are all possibilities;" and there can be little doubt that modifications in the mechanism of production exist to a corresponding degree. I have not myself come forward as the advocate of any one hypothesis, for I do not believe that anyone can be successfully manipulated so as to adapt it to all cases; nor do I attempt to broach any new theory, for I think there is no room left for further innovation, and those with which we are already acquainted, if judiciously applied, will be found amply sufficient. I should, therefore, perhaps, in conclusion, apologise for trespassing so far on the time and patience of the members of this Society in the discussion of a subject on which I do not pretend to teach anything new, and was only encouraged to do so by the belief that any contribution to the literature of this subject would be listened to with partiality by the members of the Surgical Society of Ireland, in the long roll of whose names that of Abraham Colles shall always hold one of the proudest and most conspicuous places.

